U.S. Environmental Protection Agency Region 9

- Draft- South Fork Eel Temperature & Sediment TMDLs

October 6, 1999
DRAFT

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Introduction

These TMDLs (Total Maximum Daily Loads) are water quality attainment plans for the sediment and temperature problems of the South Fork Eel River in Northern California. The TMDLs are established at levels that will meet State water quality standards for sediment and temperature, including protection of beneficial uses for native cold water fish populations. Increased sediment and summer temperatures are detrimental to native cold water fish, such as coho and chinook salmon, and steelhead. There are two complementary objectives for the report. First, the report meets legally required deadlines to identify levels of pollution control necessary to meet water quality standards. Second, the report provides the State of California's Regional Water Quality Control Board (Regional Board) with information needed to develop and implement programs to address temperature and sediment problems.

A TMDL (Total Maximum Daily Load) analysis is required by the Federal Clean Water Act, Section 303(d) because the South Fork Eel is listed as "water quality limited" due to sediment and temperature by the State of California. Under a schedule established in conjunction with a consent decree (Pacific Coast Federation of Fisherman's Association, et. al v. Marcus), the TMDL analysis for the South Fork Eel River must be approved or established by December 31, 1999. This TMDL for the South Fork Eel is the first step of a two-step process with the federal EPA establishing the TMDL and the State of California establishing the implementation plan.

These TMDLs <u>do not</u> include implementation and monitoring plans. EPA expects the State of California to develop an implementation strategy which will result in implementation of the TMDL.

The report is in four sections. Section One contains a Problem Statement which summarizes the environmental issues, provides a basin description, and provides an overview of the legal and regulatory context. Section Two is the TMDL for temperature. Section Three is the TMDL for sediment. Section Four is public participation. Appendix A is the model documentation for the SST model for temperature. Appendix B is the executive summary of the sediment source analysis for the South Fork Eel.

These TMDLs for the South Fork Eel River are the first step of the following two-step process:

1) Establishment of TMDLs by U.S. EPA, and;

2) Implementation plan by the State of California 's North Coast Regional Water Quality

Problem Statement

The South Fork of the Eel River is an important salmon and steelhead spawning and rearing area. The major water quality problem, and the one addressed in this report, is the decline of cold water fish populations. While many factors are involved in the decline of the coastal salmon and steelhead populations, we are concerned here with two inland water quality considerations - excessive sediment and increased water temperature. Not only is the fisheries' decline a significant economic and cultural loss for the region, but environmental laws are triggered when environmental degradation occurs. Under the federal Clean Water Act (Section 303(d)) in 1998 the State listed the South Fork Eel, along with many other north coast rivers, as water quality limited due to sediment and temperature concerns.

Figure 1

Basin Description

The South Fork Eel river watershed covers Northern Mendocino and Southern Humboldt counties in northern California. The 689 square mile basin stretches approximately 58 miles from the Laytonville area in Mendocino County, up U.S. highway 101 through Humboldt Redwoods State Park and the famed Avenue of the Giants in Humboldt County. The river itself winds for nearly 100 miles, flowing northward joining the Eel River near Weott. The Eel then meets the Pacific Ocean in 40 miles, about six miles south of Humboldt Bay. The watershed is known for its recreational opportunities: State Parks, white water kayaking, fishing and summer festivals draw international and local visitors alike. The landscape is varied - from gentle grassland areas and open oak woodlands removed from the coastal fog to steep slopes with deep and dense forests of redwood and fir. The land ownership is insert Land Ownership Map

Figure 2

also varied as Illustrated on Figure Two. Approximately 20% is publically owned by the California State Park system or the U.S. Department of Interior, Bureau of Land Management. Large timber companies own a relatively small percent of the watershed, mainly west of highway 101. Ranching, dispersed rural residential areas and townships make up the bulk of the area east of highway 101.

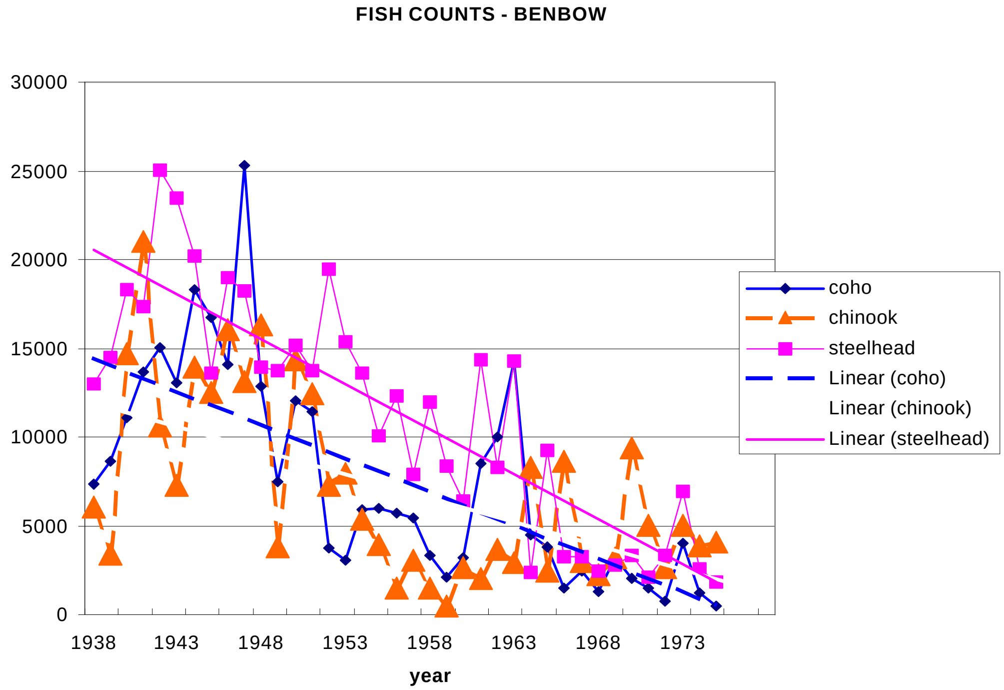
Decline of the cold water fishery

The South Fork Eel river is part of the Eel River system, the third largest river system in California. Two phases of declines have befallen the Eel River Salmon. Historically, Eel River salmon production equaled that of the Sacramento River in 1857 (Lufkin, 1996) possibly exceeding 500,000 fish (DFG, 1997); in 1904 345,800 Eel River Salmon were taken (Lufkin, 1996.) The fish harvest techniques of the era -- no restrictions on harvest and netting salmon in the rivers as they returned to their spawning grounds -- were disastrous. Already by 1910, there was concern about salmon population declines and calls to limit harvest. After crashing salmon populations made it economically difficult to compete with Sacramento salmon, the commercial inland fishery died.   In 1922 the State of California officially closed the industry, albeit after the fishery was depleted. A recreational fishery still exists; however, both declining populations and the corresponding protections for endangered species allow for only a fraction of the past fishery.

It is believed that fish populations recovered somewhat during the 1930-50s. However, a second wave of population declines followed. The Department of Fish and Game estimates that the entire Eel system, including the South Fork Eel, produced around 160,000 salmon & steelhead in 1964. By the late 1980s, only 30,000 fish were estimated to exist in the entire Eel river basin (Department of Fish and Game, 1997.)

Some of most reliable fish population trend numbers in all of northern California come from a South Fork Eel location. The Department of Fish and Game had a fish counting station from the 1940's to 1975 at Benbow, just south of Garberville. These fish abundance numbers would be a minimum population for the entire South Fork Eel watershed given that the Benbow location would not include salmon bound for more northern tributaries of the South Fork Eel.   Coho salmon show the most serious declines, approximately 17,000 coho were counted in 1945-46, but only 509 were counted in 1975 the last year the station was funded (Steiner, P. ,1998.)

Figure 3



Despite the decline, the Department of Fish and Game considers the South Fork Eel to have a significant remnant population of coho salmon (DFG, 1996.) University of California fisheries experts (Brown, 1994) found that the South Fork Eel population is important because it has little hatchery influence and thus is important for the genetic integrity of the stock. Many biologists believe that native stocks are more resilient over time in their native habitats.

This TMDL for the South Fork Eel focuses on sediment and temperature. Fish populations are influenced by many other factors, such as ocean and estuary conditions, adequate dissolved oxygen in the water column, adequate food, and adequate cover (CDF, 1994.) While this report is concerned with only sediment and temperature constraints, each limiting factor needs to be improved to increase fish populations.

Sediment problems

The amount of sediment washed through the Eel River is legendary, a process known as sediment production or yield. Most geology students are acquainted with the 1971 Brown & Ritter study that found that the Eel River was one of the highest sediment producing rivers in the world, carrying fifteen times as much sediment as the notoriously muddy Mississippi (Brown & Ritter, 1971.) While the Brown & Ritter study calculated that the South Fork Eel had proportionally less sediment than other Eel tributaries, the levels calculated are substantial. The study measured sediment yield during a time of widespread soil disturbance from road building and highly erosive timber harvest practices.

The geology of the area is naturally unstable and is generally thought to produce high natural rates and great sensitivity to human disturbance (DWR, 1983.) As in much of northern California, the large winter storms in 1955 and 1964 led to widespread flooding, landsliding and extreme changes in the rivers and streams. In the South Fork Eel, these same processes led also to the loss of old growth redwoods in the Bull Creek area (now Humboldt Redwoods State Park.) Studies conducted since that time have concluded that certain timber harvest practices and road building activities exacerbate the natural condition. This led the State Park System to acquire the entire Bull Creek watershed.

The main channel of the South Fork Eel River has filled with sediment substantially since 1964, a process known as stream aggradation. The U.S. Army Corps of Engineers measurements of aggradation show four sections of the river increased in elevation from 1.6 feet to approximately 11 feet between 1968 and 1998 (USACE, 1999.)[1] The elevation at one cross section decreased by 1.3 feet. The Army Corp report states that channel widening also appears to be continuing (1992 compared to 1996) although the trend is less evident. These types of channel changes result from both local and upstream sediment inputs.

Sedimentation of tributary streams in the South Fork Eel has also reached notable levels. Sediment from Cuneo Creek, a tributary of Bull Creek, has buried two bridges with more than 10 meters of sediment and the channel widened from 10s to 100s of meter (LaVen, 1987 and Short, 1987.) The 1964 flood resulted in widening of Bull Creek by up to 400 feet (Jager and LaVen, 1981.) Because such precise historical measurements of stream changes are rarely undertaken, there is uncertainty about the spatial extent of similar channel changes within tributaries of the South Fork Eel. DFG observers (DFG, 1996 and DFG, 1996-1998) find that some channel changes (e.g. like filling of pools with sediment) that reduce the habitat complexity needed by salmon, are frequent.

With or without changes in channel changes from increases in coarse sediment, salmon are negatively affected by the additions of fine sediment. Fine sediment smothers spawning sites, reducing the ability of salmon to reproduce successfully.

[1] One cross section increased 23 feet, however, the report recommends remeasurement of this section.

Temperature problems

Temperature directly governs almost every aspect of the survival and life history of Pacific Salmon (Berman, 1998.) Temperature is such as an important requirement of fish that coho and chinook salmon, and steelhead are known as “cold water fish”. Many physiological processes of salmon are affected by temperature including metabolism, food requirements, growth rates, developmental rates of embryos and young, timing of life-cycles such as adult migration, emergence from gravel nests, proper life stage development and sensitivity to disease (Spence et al, 1996.) In general, the types of effects are usually divided into lethal and sublethal effects. These effects are relevant for all the life stages of salmon. However, in the South Fork Eel, the most sensitive period is the summer rearing period, when young coho and steelhead stay in freshwater streams while they mature.

Stream temperatures have been measured at many locations in the South Fork Eel. It is well documented that many locations in the South Fork Eel have summer temperatures that exceed the tolerances of cold water species (see page 24 for a discussion on temperature tolerances.) Prior to this TMDL, neither the natural geographic extent of cool temperatures nor the role of human activities in reducing the amount of good cool water habitat for salmon had been established. The role of shading in preventing stream temperature increases is well established for forested ecosystems in the Pacific Northwest. However, prior to this TMDL, the role of changes in riparian vegetation has not been widely investigated for the South Fork Eel . For the South Fork Eel, given that many streams have become wider and shallower and many riparian areas have been cleared for roads or timber production, human induced changes are thought to play a large role. This TMDL determines the role of vegetation changes in altering natural stream temperatures for the South Fork Eel.

Legal/Regulatory Context

The requirements of a TMDL are described in 40 CFR 130.7 and Section 303 (d) of the federal Clean Water Act, as well as various guidance documents. EPA considers a TMDL to be a framework for identifying actions needed to meet water quality standards.

TMDLs have the following components:

- **Problem Statement**

- **Water Quality Standards**: Description of applicable numeric and/or narrative criteria. Interpretation of water quality standard into numeric water quality target(s) for TMDL identified.

- **Loading Capacity**: Identification for the pollutant and the rationale for the link between the water quality standard and the pollutant loading capacity.

- Source Analysis: Point, nonpoint, and background sources of pollutants of concern are described, including the magnitude and location of sources.

- **Allocations:** Identification of appropriate "wasteload allocations" for point sources and "load allocations" for nonpoint sources.

- Consideration of a margin of safety, seasonal variations and critical conditions, and public participation

Application of Section 303(d) of the Clean Water Act to the South Fork Eel River watershed

EPA regulations provide that TMDLs are to be established at levels necessary to attain and maintain water quality standards. In other words, the goal of a TMDL is to assure that all "beneficial uses" are protected and water quality objectives are met. Water quality objectives and beneficial uses are identified for all of the water bodies in the North Coast Region in *the Water Quality Control Plan, North Coast Region*- Region 1 (Basin Plan.)

In addition to drinking water, municipal, industrial, and recreational uses of the South Fork Eel River, the Basin Plan identifies the following beneficial uses that relate to the cold water fishery:

- Commercial and sport fishing
- Cold freshwater habitat
- Migration of aquatic organisms
- Spawning, reproduction, and early development

The cold water fishery is the most sensitive of beneficial uses in the watershed. As such, protection of these beneficial uses is presumed to protect any of the other beneficial uses that might also be harmed by sedimentation or increased temperature.

Water Quality objectives further define the goals for the South Fork Eel. The Basin plan for the North Coast Region has objectives related to both the sediment in and the temperature of North Coast streams, including the South Fork Eel. The objectives are described in the appropriate sections on temperature and sediment, along with any interpretation that is necessary to complete a TMDL.

Analytic Framework

This report contains separate TMDLs for both sediment and temperature. These problems are interrelated because sediment problems can also lead to increased stream temperatures primarily by widening the stream. Figure 4 illustrates these interrelationships. In addition, loss of riparian vegetation (the major reason for increased stream temperature in the South Fork Eel) can also lead to increased sedimentation by changing bank stability.

The primary technical information underlying both temperature and sediment TMDLs is a study funded by EPA in 1998-1999. EPA funded a study by Stillwater Associates for additional data collection, analysis and modeling of sediment and temperature problems in the South Fork Eel.

Insert temp/sdidment graphic

Temperature

The State of California listed the South Fork Eel as “impaired” due to both sediment and temperature problems. This section will address the temperature problems that affect cold water fish; sediment problems will be addressed in Section Three. A TMDL describes the extent of actions needed to meet water quality standards. The State of California has established two water quality objectives that must be met for temperature in the South Fork Eel. The following steps were used to develop the temperature TMDL for the South Fork Eel - each step will be described late in this section.

1- Analysis of the source of stream temperature increases focused on modeling the effects of changes in streamside (e.g. riparian) vegetation. Existing stream temperatures were modeled for three representative subbasins - Bull Creek, Rattlesnake Creek and Elder Creek.

2- The narrative temperature standard was interpreted into stream temperature goals for all three subbasins. For example, 38% of stream kilometers in the Bull Creek subbasin should support good cool water habitat.

3- Stream temperature goals were translated into a modeled **<u>heat load</u>** to meet the loading capacity requirement of a TMDL.

4- Effective shade targets were determined for individual stream types to meet the requirements for setting TMDL allocations. These effective shade targets vary by stream width and site potential vegetation.

Step One: Investigating the source of stream temperature increases

Stream temperature can be affected by many variables, including changes in flow from diversions and dam releases, increases from heated water entering the stream (for example, in the case of irrigation return flows), groundwater flow changes and solar radiation. In the South Fork Eel, a river without any major dams, diversions, or return flows, the primary heat inputs are from direct solar radiation and groundwater flow. Stream heating in excess of natural levels arises primarily from local increases in solar radiation due to removal of streamside vegetation, and the transport of excess heat downstream.

To determine the source of stream temperature increases in the South Fork Eel, EPA used a model developed by Stillwater Sciences, called Stillwater Sciences Temperature Model (SSTM.) Although, field measured stream temperatures were available for many locations in the South Fork Eel, it is useful to supplement this information with modeled information. A model can predict stream temperatures over all the stream lengths and a model can be used in testing different management scenarios. Modeling of stream temperatures is a credible, well-developed field of scientific endeavor with many practical applications to societal decisions.

Using field data collected at a variety of locations in the South Fork Eel by the Humboldt County Resource Conservation District, SST modeled the temperatures for the entire stream network in three subbasins that represent stream and vegetation types in the entire South Fork Eel - Bull Creek, Rattlesnake Creek and Elder Creek. SST expresses stream temperatures using the Maximum Weekly Average Temperature (MWAT) metric. Although many models exist, the SST model was developed to allow for examination of stream temperature changes at the basin scale when little field measured data exists.

Summary of Stillwater Model

Appendix A provides a technical description of the model and data sources. The summary of the model presented here is intended for a more general audience and many aspects of the model are simplified. The SST model calculates stream temperatures for the months of July and August when stream temperatures are at their maximum and of most concern to salmon production. SST model uses existing computerized maps of data (known as GIS data) on topography, the stream channel network, and vegetation to determine the heat from direct solar radiation reaching each individual stream segment. Vegetation data was simplified and converted from diameter classes to assumed heights. The model then solves a heat balance equation for each stream segment, calculating the net effects of direct solar radiation, heat exchange processes at the water surface, and water flow in and out of the water segment.

Data collected by Humboldt County RCD and cooperators allowed for both model development and validation of the model's predictive capabilities. SST model concentrated on three subbasins - Bull Creek, Elder Creek and Rattlesnake Creek. The stream temperatures and vegetation characteristics in the three subbasins modeled are representative of the range of conditions found in the South Fork Eel.

Model Results

Statistical analysis of the predicted versus measured temperatures show that the model is performing well in these three subbasins. Figures 5-7 show the predicted current stream temperatures in each of the three basins, along with statistics on model performance. The performance of the model demonstrates that we are capturing the major source of stream temperature in the South Fork Eel - riparian vegetation. These maps have divided up stream temperatures into 2 C temperature classes with the color codes matching our general assessment of habitat conditions for salmon (see page 24 for a discussion on MWAT temperature thresholds for salmonids.)

Blue = good cold water habitat,
Green = marginal cool water habitat
Yellow = poor cool water habitat
Pink/red = inadequate habitat.

The maps show that the South Fork Eel provides a variety of habitat conditions currently, from good to marginal to poor to inadequate. Figure 8 shows the model's performance over the range of stream temperatures modeled.

Summarizing Stream Temperature - Use of the Maximum Weekly Average Temperature Metric (MWAT)

Because temperatures in streams fluctuate daily and seasonally, it is useful to summarize this detailed variability with a summary measurement. To assess stream temperatures in this TMDL, we use the Maximum Weekly Average Temperature (MWAT), the most widely used measurement. MWAT is calculated here as the maximum week of the 7 day running average of all monitored temperatures. Readers should note that the term MWAT is not used consistently by researchers and agencies.[2] Examination of MWATs in South Fork Eel streams allowed researchers to simplify modeling by using the last week in July as the most sensitive period, after finding that the vast majority of stream temperatures in the South Fork Eel had MWAT during this week.

[2] Contrast this with Oregon DEQ's MWAT which is calculated as the maximum week of the daily maximum.

Insert Figures 5-

figure 6

figure7

figure8

Step Two: Interpreting the existing water quality standards for temperature for the South Fork Eel

The second step in the temperature TMDL analysis was to interpret the State of California's water quality standard. The Basin Plan identifies the following temperature objectives for surface water:

> ***"The natural receiving water temperature of intrastate waters shall not be altered unless it can be demonstrated to the satisfaction of the Regional Water Board that such an alteration in temperature does not adversely affect beneficial uses."***

> ***"At no time or place shall the temperature of any COLD water be increased by more than 5 degree F above natural receiving water temperature."***

Using the above interpretation of the water quality standard for temperature for the South Fork Eel, the following stream temperature goals were developed:

TABLE ONE:
<u>Stream Temperature Goals</u>
- percent of stream by cold water habitat type -
- percent of stream kilometers-

Cold water habitat	Bull Creek	Elder Creek	Rattlesnake Creek
Good < 15°	37%	38%	0%
Marginal 15-17°C	31%	52%	1%
Poor 17-19°C	18%	10%	21%
Inadequate 19-21°C	14%	0%	55%
>21°C	0%	0%	23%

These temperature goals were developed by choosing a "natural condition" scenario from a range of possible modeled vegetation conditions**.** EPA also examined the amount of cool water habitat to determine if these "natural conditions" could be altered without "adversely affecting beneficial uses." The following sections explain the analysis used.

What is natural receiving water temperature?

The SST model was used to examine the likely natural conditions on Bull, Elder and Rattlesnake Creeks. Natural was interpreted as natural vegetation characteristics of the South Fork Eel. Because no GIS data exists on the original vegetation of the South Fork Eel, different modeling scenarios were developed to answer this question. First, SST model developed a series of curves for all the possible scenarios. These scenarios were called “relative shade scenarios”. The scenarios ranged from removing all riparian vegetation, where topography provides all the available shade (labeled 0% relative shade) to “100% relative shade”, where the current type of vegetation was modeled to reach it’s oldest and tallest state. Figures 9-11, display the results of all scenarios. These curves illustrate that there is no vegetation scenario that provides either all poor habitat or all good habitat in all three subbasins. Table 2 displays the same results numerically. EPA concludes:

- Even under the most idealized potential vegetation conditions, stream temperatures in the South Fork Eel varied from 13->21C. This range of stream temperature spans the range of good to marginal to poor conditions for salmon.

- Changes in riparian vegetation results in significant changes in stream temperatures in the South Fork Eel.

The “natural” condition scenario examined these modeled vegetation scenarios and then chose one scenario as the “natural condition.” The idealized vegetation scenario was not chosen as the “natural” condition. The idealized vegetation scenario (modeled by SSTM as 100% relative vegetation) assumes a landscape prior to livestock grazing, timber harvesting and road building in the South Fork Eel. This involved converting existing vegetation data to the oldest and tallest vegetation stage, known as late seral, for each existing type of vegetation. The potential riparian vegetation of grassland areas is modeled as alder and willow. However, under natural conditions, fire and storms would naturally impose variety in the riparian zone to some extent (Bureau of Land Management, 1996.) In addition, the SSTMs conservative assumptions on vegetation were considered unrealistic. EPA used conditions in Elder Creek as a point of comparison because Elder Creek is a relatively undisturbed stream in the South Fork Eel. Elder Creek is not a untouched watershed, it consists of small residential areas and dirt roads managed by the University of California. Current conditions in Elder Creek were compared to modeled idealized conditions. Current stream temperature conditions in Elder Creek are approximately equal to a riparian condition of 85% of idealized modeled potential shade. Thus, the 85% potential shade condition was used to interpret the “natural” clause of the water quality standard. Using Elder Creek as a reference does not impose Elder Creek vegetation conditions on the entire basin, rather the 85% goal is applied to whatever vegetation type exists currently in other tributary basins.

Figure9

figure 10

figure 11

INSERT TABLE TWO: SHADE SCENARIO RESULTS

Could “natural” temperatures be increased without adverse effects on salmon?

After examining “natural” conditions, EPA investigated whether or not natural temperatures could be increased without “adversely affecting beneficial uses.” To paraphrase the standard *“natural temperatures shall not be altered unless they do not adversely affect beneficial uses.”* As discussed below, based on our comparison of stream temperatures in the South Fork Eel and the science on adverse effects on salmon, we conclude that cold water habitat is so limited in the South Fork Eel that natural temperatures **cannot** be altered without adversely affecting beneficial uses.[3] This conclusion is not affected by choosing a threshold of concern of >15 °C or >17° C.

Temperature directly governs almost every aspect of the survival and life history of Pacific Salmon (Berman, 1998.) Many physiological processes of salmon are affected by temperature including metabolism, food requirements, growth rates, developmental rates of embryos and young, timing of life-cycles such as adult migration, emergence from gravel nests, proper life stage development and sensitivity to disease (Spence et al, 1996.) When stream temperatures increase, the viability of native cold water fish decreases. In the South Fork Eel, the most sensitive period is the summer rearing period, when young coho and steelhead stay in freshwater streams while they mature.

Determining adverse effects on beneficial uses focused on reviews and summaries of the literature on temperature tolerances for salmon. While this literature provides a well-founded basis for determining good habitat conditions for salmon, there is no consensus on precise thresholds for “adverse affects” measured by summarizing metrics (like the MWAT measure used in this analysis.) There are two major elements that cause a divergence over precise thresholds. First, there are differences between researchers and agencies on how to apply the temperature data from lab studies to a summary measurement of actual stream temperatures. Second, thresholds have different uses and meanings. In this TMDL, we have not attempted to add to the discussion, instead we simply compile thresholds developed in other forums and use them for discussion purposes.

Review of several temperature thresholds of concern for coho, chinook and steelhead ascertained that there are differences by a few degrees; none of these distinctions are significant for this study. Regional Board staff developed a proposed MWAT threshold of concern for the Garcia of 17.1°C (Manglesdorf, 1998.) The Regional Board uses the procedure from Armour, 1991. That procedure sets

[3] It is theoretically possible for cool stream temperatures to be so widespread that a reduction in the amount of cool water habitat will not affect beneficial uses. This condition is more likely in the northern range of coho (e.g. Alaska) and unlikely in California.

thresholds of concern by scaling lab preference data upwards using a formula. The State of Oregon temperature standard is a MWAT of 17.8°, but this is measured as a daily maximum, not as in California, as the average of all the temperatures in a week. Oregon underwent the most recent review of its standard and concerns were expressed by EPA's Seattle's office over the protectiveness of the standard. Given that the standard included habitat that was not optimal and was linked to the MWAT metric that averages out other stressful temperatures, EPA felt it was not protective in the case of endangered species (Berman, 1998.) The National Marine Fisheries Service concluded that < 14° C was properly functioning, 14 - 17.8 °at risk and > 17.8 °not properly functioning. These numbers cannot be directly compared for "toughness" because the threshold of concern can imply either a policy on the maximum allowable (e.g. Regional Board and ODEQ) and thus encompasses habitat that is not optimal or most productive, or a range of concerns (e.g. NMFS.) The way the thresholds will be used plays an important role in understanding why thresholds vary.

Using the above information, we display our MWAT information in 2 C temperature breakpoints with the color convention generally matching our assessment of the quality of cool water habitat.

Good Cool Water Habitat - shades of blue - <15° C
Marginal - green - 15 -17° C
Poor - yellow - 17- 19° C
Inadequate - pink - 19 - 21° C

EPA reviewed both the extent of current habitat and likely natural conditions using these temperature breakpoints as a general guide. Given that the natural good and marginal cool water habitat is limited in the South Fork Eel, we find that increases to the natural condition <u>cannot</u> be increased without affecting beneficial uses. This judgment was also informed by the relative importance to coho of the South Fork Eel within the North Coast of California (Brown et. al., 1994.) This judgement would not change if we considered all the marginal habitat to be as productive as the good cool water habitat. Thus using either a threshold of concern of < 15 °or <17 °C results in the same conclusion. In addition, even within smaller cooler tributaries, like Elder Creek, good cool water habitat is too limited to allow increases in the natural condition. In the absence of information on the characteristics of other tributary basins, stream temperature goals are not proposed.

Using the above interpretation of the water quality standard for temperature for the South Fork Eel, the stream temperature goals are presented again in Table One:

TABLE ONE:
Stream Temperature Goals
- percent of stream by cold water habitat type -
- percent of stream kilometers-

Cold water habitat	Bull Creek	Elder Creek	Rattlesnake Creek
Good < 15°	37%	38%	0%
Marginal 15-17°C	31%	52%	1%
Poor 17-19°C	18%	10%	21%
Inadequate 19-21°C	14%	0%	55%
>21°C	0%	0%	23%

EPA also used the SST model to investigate whether the 5° F prohibition in the basin plan is currently exceeded in the South Fork Eel. Mapping the changes in temperature between current conditions and idealized potential vegetation showed the 5 F condition is not a concern. Therefore, this water quality objective was not investigated further.

Determination of pollutant load capacity

Under the TMDL framework, identification of the “loading capacity” is a required step. The loading capacity provides a reference for calculating the amount of pollutant reduction needed to meet water quality standards. In this TMDL, we express the loading capacity as heat units. Heat is a pollutant under the Clean Water Act. (Recall that the model links the riparian shade condition to stream temperatures by determining how sunlight is converted to stream heat (pollution) through anthropogenic changes in stream side vegetation.) These heat units do not have a management purpose. Rather the management unit is the effective shade. The loading capacity heat units explicitly clarify the role of modeled heat, a pollutant, in stream temperature.

Stillwater calculated the nominal heat energy content of direct sunlight for the “current condition” and “natural condition” scenarios. This differs from the actual energy that would be observed in the field, because of the scale of the model. Because the modeled values relationship with true values has not been determined, the heat units is not measurable or enforceable. However, it is adequate for making relative comparisons between basins or between scenarios. Recall that this natural condition scenario is the interpretation of the water quality standard, therefore, the loading

Insert Figure 12 - heat loding capacity

capacity will meet this same standard. Figure 12 presents the heat loading capacity in the subbasins and the entire watershed. This calculation meets the CWA requirement to determine the "greatest amount of loading that a water can receive without violating water quality standards."

Pollutant load allocations - Effective shade targets

Effective shade targets are proposed as the "allocations" (e.g. management measure) needed from individual stream segments. Oregon Department of Environmental Quality introduced the approach of using effective shade targets in several proposed and final TMDLs (ODEQ, 1998; ODEQ, 1999.) Effective shade is a function of vegetation height, stream width and/or topographical barriers. Effective shade is measurable and site specific variables, such as site potential riparian vegetation, can be determined during implementation.

Effective shade targets meet the legal requirement to set pollutant load allocations. The South Fork Eel TMDL incorporates measures other than "daily loads" to fulfill the requirements of the Clean Water Act 303 (d). Alternative measures to mass/time are known as "other appropriate measures" and are allowed under EPA regulations (40 CFR 130.2.)" Although a loading capacity for heat is derived, it is of limited value in guiding management activities needed to solve identified water quality problems. Therefore, the load allocations are expressed as effective shade, which can be measured with various devices, such as solar pathfinders or fish eye lenses. Table 3 indicates the effective shade targets for the South Fork Eel.

TABLE THREE: Effective Shade Targets by vegetation and stream width

Table 3:	**Effective Shade Targets**					
WHR Forest Type	1-2 meter stream width	2-5m	5-10m	10-15m	15-20m	20-30m
Mixed Conifer	96	91	82	68	52	37
Mixed Hardwood/Conifer Conifer dominated	96	90	79	67	49	33
Mixed Hardwood/conifer Hardwood dominated	96	90	79	66	49	33
Mixed Hardwood	95	90	78	65	47	33
Mixed Oak Woodlands	95	89	78	64	44	26

Stillwater Sciences calculated these effective shade targets using the "natural condition" scenario and an appropriate formula for rescaling insolation values from the models 30 meter scale to the stream width classes shown on Table 3. It may be useful to reiterate that a primary factor used in calculating the "natural condition" scenario is the 85% relative shade discussed previously. The 85% relative shade factor was developed by comparing current conditions in Elder Creek to the modeled idealized 100% relative shade scenario. This approach does not impose the vegetation characteristics of Elder Creek on the entire watershed, rather the 85% scenario is applied to whatever vegetation type exists. In addition, the model implicitly accounts for shading provided by topography.

Given that field verified site conditions were not available to EPA, the proposed approach uses the vegetation type class based on WHR classes (see Appendix A) as default targets. However, EPA recommends that during implementation planning, a process for using site specific data that refines these default assumptions be instituted. These assumptions are presented in Table 4.

Table 4: Default vegetation assumptions

Vegetation type -WHR class-	percent of South Fork Eel	Current - mean height (m)	Site Potential - mean height (m)
Mixed Conifer	14%	37	37
Mixed Hardwood/Conifer Conifer dominated	41%	23	30
Mixed Hardwood/conifer Hardwood dominated	36%	19	34
Mixed Hardwood	5%	15	30
Mixed Oak Woodlands	4	9	25

The role of Class II streams in stream temperature increases was also examined explicitly. Class II streams are defined under the Forest Practices Rules as non-fish bearing streams. We investigated whether these streams were important to the temperatures of fish bearing streams. Specifically, Bull Creek was modeled under different scenarios to determine the magnitude of influence from Class II streams. Table 5 and Figure 13 show the results of this analysis. The results indicate that Class II streams are important to the temperatures of Class I streams and should be protected.

Table 5

- class i/II

figure 13 - class I/II

Margin of Safety

Legally, a margin of safety is required in setting TMDLs under the Clean Water Act 303 (d) program. A margin of safety can be an explicit number incorporated into the TMDL calculation and/or conservative assumptions used to develop the TMDL.

This report analyzes sediment and temperature effects separately. Any improvements in stream temperature from reduced sedimentation (or vice versa) are not calculated explicitly, instead the cumulative benefits are a major portion of the margin of safety.

1. Proposed changes in riparian vegetation toward larger trees will likely provide, over time, increased large woody debris. Large woody debris benefits cool water habitat by increasing the number and depth of pools and other changes in channel complexity. These changes were not accounted for in the analysis and the benefits provide a margin of safety.

2. Likely improvements in channel morphology, such as stream narrowing, could also reduce stream temperatures due to reductions in human -induced sediment. These possible stream temperature reductions are not accounted for in the analysis and would be additional to those detailed in the separate analyses on sediment and temperature.

3. Improved riparian areas may increase summertime flow augmentation by increasing the volume of water stored in riparian areas and slowly released during low flow conditions. Water stored as groundwater is cooled by the absence of solar radiation.

In addition, EPA concludes that uncertainties associated with the use of MWAT metric will not influence the TMDL analysis. Researchers are questioning whether MWAT metric captures the most important temperature conditions for fish to thrive. Researchers are concerned because averages can hide very different temperature fluctuations, including higher biologically stressful temperatures. Salmonids respond not only to daily maximum temperatures, but also to daily maximum fluctuation and cumulative temperature exposure (Berman, 1998.) Thus weekly averages could theoretically be supplemented with calculations on the duration and magnitude of exposures to different temperatures (Coutant, 1999; Berman, 1998). However, because this TMDL focused on the “natural condition” of the riparian vegetation and set allocations accordingly, any measurement of cold water habitat would also meet the “natural condition” determination.

Seasonal Variation

This TMDL is set to achieve water quality standards in the season considered to be most problematic in the South Fork Eel - summer maximum temperatures. EPA also maintains that the use of summer temperatures as the period of analysis will provide protection for any other life stages that may be affected by changes in temperature. This is because changes toward more natural vegetation conditions will change the temperature regime during all seasons to a more natural condition, thus protecting any other disrupted temperature regimes. In the South Fork Eel, salmon are adversely affected by summer temperatures.

Monitoring and Implementation

Monitoring questions were not investigated for the TMDL. However, the implementation phase needs to address questions of: What is the best measurement technique for riparian condition targets? What would be appropriate stream length or averaging? How would stream width be measured?

In addition, an underlying assumption is that effective shade targets are set equally across the landscape, dependant only upon potential vegetation and stream width. EPA used this assumption because of equity concerns and analytic simplicity. Using this strategy, every stream segment has the same potential shade goals (85% of idealized). However, it is possible in theory, that the same amount of cool water habitat be provided more cost effectively by larger landowners by distributing potential vegetation in differing manner (example, certain sites at 95% of potential and others at 75% of potential). Implementation planning may also want to consider this type of flexibility.

EPA recommends that an implementation plan include provisions to improve the underlying default assumptions on vegetation characteristics and site potential. These assumptions underlie the temperature goals for the basin and need to be widely examined. In addition, even with a widely reviewed characterization of vegetation and potential, the implementation plan should include provisions to use site specific information instead of the default assumptions on vegetation.

EPA recommends continued monitoring of stream temperatures in the South Fork Eel. We have found analysis of stream temperature data could benefit from several considerations in the monitoring phase. First, very meticulous mapping of the location of the temperature monitors is needed. This is in addition to GPS coordinates and especially important when monitors are located near the junction of two streams. Explicit recording of the upstream/downstream location is needed. In addition, spot measurements of summer low flow conditions would improve analysis effects as would groundwater temperature measurement. More temperature gauges should also be located in non-fish bearing streams (Class II streams) because these areas have an influence on temperatures further down in the stream network.

SEDIMENT TMDL FOR THE SOUTH FORK EEL

The State has identified the South Fork Eel as water quality limited due to sediment as well as temperature. The primary environmental concern is the decline of populations of native cold water fish, such as coho and chinook salmon, and steelhead. Increases in sediment affect these fish in a variety of ways. Fine sediment diminishes spawning success by reducing the survival of salmon young through the egg stage to their emergence from their gravel nests (called redds) Coarse sediment can overload the ability of the stream to process sediment load and change the streams shape (or morphology.) These structural changes simplify the natural complexity and stability of instream habitat resulting in reduced survival of salmon. For example, juvenile rearing success is diminished by reducing pools and cover as streams become shallow and wide, and spawning success is reduced as unstable streams scour and wash away the gravel nests of salmon (Bauer & Ralph, 1999.)

The primary purpose of the South Fork Eel River Total Maximum Daily Load for Sediment (TMDL) is to identify the maximum allowable amount of sediment that is needed to meet water quality standards. The water quality standard for sediment requires that sediment "not adversely affect beneficial use." The primary beneficial use of concern is native cold water fish.

EPA funded a sediment source analysis (Stillwater Sciences, 1999) in order to provide information on the sources and magnitude of sediment in the South Fork Eel. (The executive summary of the sediment source analysis is included as Appendix B.) A pollutant source analysis demonstrates that all pollutant sources have been considered. Information from the sediment source analysis was used in setting TMDL loading capacity and allocations.

The major components of the TMDL analysis are:

- Narrative water quality standards were interpreted into a small set of measurable indicators: percent fines, V* and thalwag profile.

- Sediment loading was estimated as twice the natural rate. For every tonne/km2/year of natural sediment, there is one tonne/km2/year of human-induced sediment. The study found that sediment loading is variable in the South Fork Eel basin and roads are the largest contributor of human-induced sediment.

- The loading capacity for sediment was set based on estimates of increases above natural sediment loading from the hillslope. The TMDL is set at 1:4 ratio of human:natural sediment.

- Load allocations were established. These calculations illustrate that meeting basin sediment reduction goals necessitate ambitious erosion control plans. In order to meet a 1:4 ratio of human: natural sediment, current estimates indicate that sediment from roads will need to be reduced by 80% and sediment from increased landslides by 55%.

Interpreting the water quality standards - Numeric Targets for Sediment

In order to analyze how much sediment is too much, the water quality standards for the North Coast need to be interpreted in light of what "does not adversely affect" salmon. For a recent examination of the proper role of these types of numeric targets see "Aquatic Habitat Indicators and their Application to Water Quality Objectives within the Clean Water Act" (Bauer & Ralph, 1999.)

The approach taken for the South Fork Eel is to propose relatively few indicators that interpret water quality standards for sediment. In addition, these indicators can be used as diagnostic indicators -- as a sign to look further -- and should not be interpreted as definitive evidence or lack of evidence of salmon habitat effects.

Numeric targets interpret water quality objectives, provide indicators of watershed health, and represent habitat conditions adequate for the success of salmonids. The water quality objectives for erosion related concerns of suspended material, settleable material, sediment, and turbidity are found in the North Coast Regional Water Quality Control Board's Basin Plan. In addition, two prohibitions on logging, construction and related activities further define water quality-related requirements.

The water quality objectives for these four sediment-related pollutants are as follows:

> *"Waters shall not contain suspended material in concentrations that cause nuisance or adversely affect beneficial uses."*

> *"Waters shall not contain substances in concentrations that result in deposition of material that causes nuisance or adversely affect beneficial uses."*

> *"The suspended sediment load and suspended sediment discharge rate of surface waters shall not be altered in such a manner as to cause nuisance or adversely affect beneficial uses."*

> *"Turbidity shall not be increased more than 20 percent above naturally occurring background levels. Allowable zones of dilution within which higher percentages can be tolerated may be defined for specific discharges upon the issuance of discharge permits or waiver thereof."*

In addition to the water quality objectives, the Basin Plan includes two discharge prohibitions specifically applicable to logging, construction and other activities associated with increased erosion. They state:

> *"The discharge of soil, silt, bark, slash, sawdust, or other organic and earthen material from any logging, construction or associated activity of whatever nature into any stream or watercourse in the basin in quantities deleterious to fish, wildlife, or other beneficial uses is prohibited."*
>
> *"The placing or disposal of soil, silt, bark, slash, sawdust, or other organic and earthen material from any logging, construction, or associated activity of whatever nature at locations where such material could pass into any stream or watercourse in the basin in quantities which could be deleterious to fish, wildlife, or other beneficial uses is prohibited."*

Instream Numeric Targets

Two broad categories of adverse sediment effects are important: changes in channel structure from coarse sediment, and increases in fine sediment. Fine sediment can adversely affect salmon production, even without changes in channel structure. But both types of change affect salmon spawning and rearing success. EPA is proposing indicators for both fine sediment and coarse sediment/channel structure. The indicators are: percent fines, V* (vee-star) and thalwag profile.

Indicators of Fine Sediment: Percent Fines and V*

Fine sediment can negatively affect both salmon spawning and rearing. Many researchers have identified relationships between the amount of fine sediment in spawning gravel and salmonid survival to emergence (see Stillwater, 1999 for a review of the literature.) Different methods of determining the quality of spawning gravel exist, as does different sampling methods and a variety of summarizing statistics. These indices include: measures of the mean diameter (D50, D8 etc.), different measures of percent fines, and the fredle index. Some researchers caution against using just one measure of gravel quality. However, because gravel measurements are costly, we are proposing percent fines as the only indicator for the South Fork Eel given the amount of land in small private holdings.

Percent Fines

Percent fines is defined as the percent of subsurface fines <0.85 mm and 9.5 mm. Monitoring methods (sample location, reach length, frequency, extraction method, size of sampler) are not standard at this time, but need to be thoroughly researched and reported. The numeric target for fine <.85mm is less than or equal to 14%. The target is selected as the midpoint between the percentage of fines reported in unmanaged streams in the Peterson (1992) and Burns (1970) studies. This indicator is expected to be sensitive to the type of channel, especially channel slope and the preceding rainfall patterns. Therefore, the indicator should be used within an analysis of the preceding hydrological conditions and channel type.

V*

V* (pronounced “vee star”) is a measure of the fraction of a pool’s volume that is filled by fine sediment and represents the in-channel supply of mobile fine sediment (Lisle and Hilton, 1992). This measure may also be a good indicator of rearing habitat as mobile bedload sediment fills pools and simplifies the complex habitat needed for salmon rearing. This indicator is also sensitive to channel type, preceding flow events and local variations in sediment supply (Stillwater, 1999.) Some previous TMDLs used Knopp’s findings of V* values of 0.21 (21%) which represent good stream conditions (Knopp, 1993). Sample sites for this study were located in Franciscan geology. However, Knopp’s data were collected following 5-7 years of below-normal precipitation, which may result in relatively high levels during this period compared to higher rainfall periods. In a recent Lisle and Hilton (1999) study, Elder Creek, an undamaged basin in the South Fork Eel was sampled. The reach-mean V* was approximately 0.09 (9%.) Stillwater Sciences sampled 24 pools in 11 streams in the South Fork Eel in September 1998, including Elder Creek. This period was after substantial high El Nino flows. Elder Creek had V* of 1-2%. This illustrates the substantial natural variability that exists with any sediment indicator. Bauer and Ralph (1999) recommend that future indicators be expressed in terms of the central tendency and spread in the data to better account for natural variability and improve the interpretation of the data. We propose a V* target of <0.10 (10%) threshold for concern for streams in the South Fork Eel, but specifically invite public comment on improved methods to express the natural variability. Given the sensitivity to preceding flows, V* should be monitored over time. In the September 1998 Stillwater sampling, several streams with much historical disturbance had V* under the proposed threshold of concern of <10% (Bond, Bear Wallow and Hollowtree) possibly indicating that these areas are recovering from prior sedimentation. On the other hand, Bull Creek, South

Fork Salmon Creek and the East Branch of the South Fork Eel all had V* of 20-25% indicating areas with fine sediment concerns.

Thalwag profile - indicator of channel changes and coarse sediment

Changes in channel structure are very important to salmon survival. Habitat complexity within channels consisting of pools, cover, large woody debris, backwater pools, all interact to provide salmon with good rearing habitat and possibly, overwintering survival. The gross simplification of habitat as evidenced by streams becoming wide and shallow and filling with sediment, is a measurable phenomenon, albeit within much natural variability, both within and among streams. Measures of channel complexity include: pool frequency, residual pool depth, pool/riffle ratio, width/depth ratio, large woody debris frequency and thalwag profile. Bauer and Ralph recommend the use of residual pool depth as an effective numeric indicator of habitat conditions, particularly if stratified by basin size and stream gradient. However, given that no stream stratification scheme for the South Fork Eel has been developed, EPA proposes thalwag profile because this measurement has fewest measurement concerns. Many pool and large woody debris measurements are not standard, prone to measurement inaccuracies and are flow dependant. Repeated surveying of cross sections is a widely accepted, standardized method and has proven its utility in evaluating channel stability and sedimentation effects (Klein, 1998.) Thalwag profiles can also be used to evaluate pool frequency and depth (Klein, 1998 reporting Madej.)

The thalwag profile is a profile, measured parallel to stream flow, of the lowest elevation of each of many channel cross-sections. As a stream descends from its headwaters to its mouth, the mean thalwag profile slope also descends. As the number of pieces and volume of large woody debris increases as well as the number and depth of pools, the thalwag profile develops more dramatic variation around the mean profile slope. We propose increasing variation as the target condition, defined as increasing variation in the thalwag elevation around the mean thalwag profile slope.

In addition to these indicators, EPA specifically invites public comment on the use of residual pool depth and hillslope targets.

Sediment Source Analysis

Watershed characteristics

Sediment production is a function of geology, topography and land use. The South Fork Eel has three major types of land uses - timber production, rural residential and grazing areas. Figure 2 (page 3) illustrates the relative proportions of land in public ownership, large timber companies or small private residential ownership. The actual uses of the lands characterized as mixed residential is difficult to determine because centralized information is not available and local residents have privacy as a deeply held value. It is generally assumed that these privately held lands are composed of grazing, and private residential areas. Both these private parcel types may occasionally harvest timber.

Geology and topography are both important in understanding sediment production. The basin can be stratified into three major geomorphic terrains, which at a gross level overlap with vegetation and then land use. The sediment source analysis stratified the basin into three major “geomorphic terrains” (see Figure 14), that is areas that are expected to have similar rates of sediment production due to their similarity in geology and topography. The Yager and coastal belt franciscan terrains are characterized by moderate to steep slopes and forested hillsides with straight profiles. The melange areas character is open grasslands and oak woodland with land forms that are often described as rolling, hummocky, and “melted ice-cream scoops”. The melange is found in the eastern portion of the basin and has little, if any, associated timber production.

Summary of the Sediment Source Analysis

The sediment source analysis combined several methods to generate estimates of sediment in the South Fork Eel. Earlier studies were summarized, limited photo analysis and field work was conducted, existing data was improved by several modeling techniques, and GIS data analysis was used. A major focus of the sediment source analysis is to better characterize the proportion of human-induced sediment. The study intensively studied three areas representative of different types of geology and hillslope stability within the South Fork Eel (see Figure 15.) Certain information from these “geomorphic terrains” was part of the extrapolation of sediment estimates to the entire basin. Appendix B, the executive summary of the Sediment Source Analysis, is a detailed description of the study, methodology and results.

The most recent time period analyzed in the Sediment Source analysis, 1981-1996, is used for this TMDL. The emphasis on more recent events was deliberate.

Figure 14 - terrains

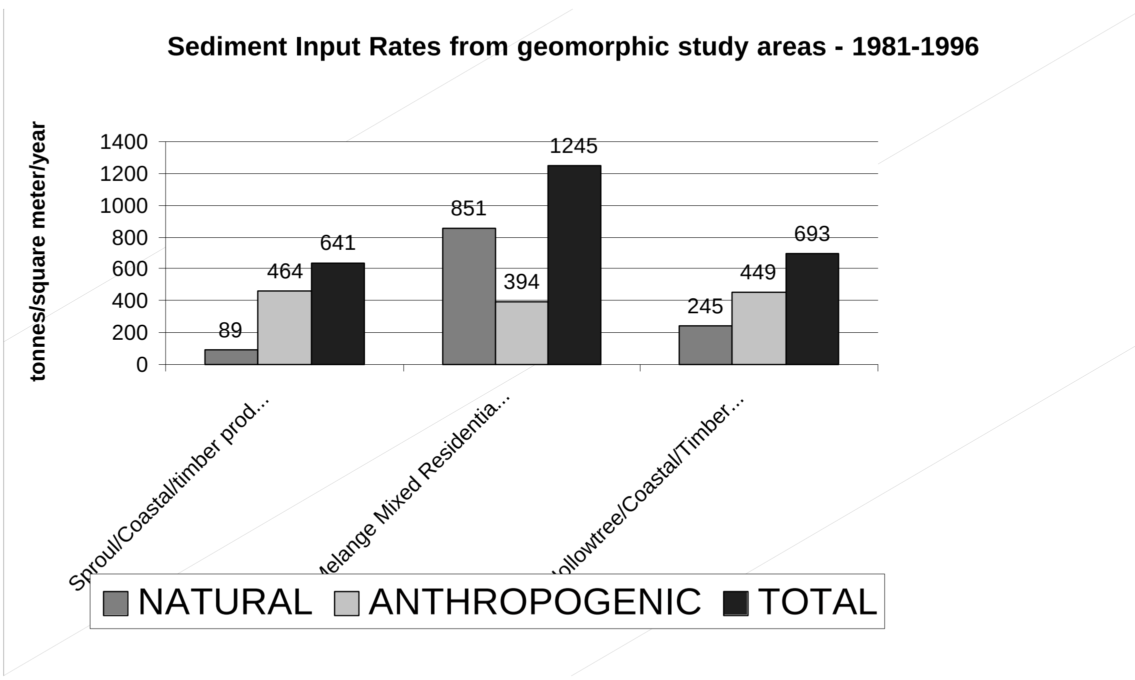
Figure 15 Intensive areas

Given limited time and resources, estimating more recent periods allows an investigation into current land uses practices. However, this benefit was traded against the concern that the more recent period was characterized by milder winter storms (intense storms are triggers for sediment movement.)

The location of the three intensive areas is shown on Figure 15. The Sproul creek area is representative of coastal geomorphic terrains that are more stable. These areas have recent timber harvest. The Hollowtree area is representative of a steeper coastal belt geomorphic terrain also in industrial timber production. The Tom Long area is in mixed melange terrain. This area is primarily rural residential mixed with grazing and a small amount of timber production (see Appendix B.)

Figure 16 displays the variability of sediment loading in the three intensive areas in the South Fork Eel. The total amount of sediment varies with geomorphic terrains from 640 - 1200 t/km2/year for the most recent period. The mixed melange area studied had nearly twice the estimated sediment loading to streams. This area is in the eastside of the basin and overlaps with the mixed residential use. There is little timber production in these mixed areas. (For more information see Appendix B.)

Figure 16



Insert Figure 17 piecharts

The importance of sources of sediment varies by subbasin. Figure 17 shows the relative magnitude of different erosion sources in each subbasin. Natural inputs range from 16 - 67%. Geology and topography influence these natural processes. The large amount of natural sediment production in the mixed melange area is from earthflow toes and associated gullies. Timber harvest inputs' (exclusive of roads) range from 7% (in areas with little harvest) to 23% of total sediment production. Timber harvest techniques and the rate of harvest influence this process; the areas studied either did not have much recent harvest activity or use improved harvest techniques. Thus the relatively low proportion from harvest (exclusive of roads) is not inherent in all harvest techniques. Roads account for the largest amount of human induced sediment and the largest overall sediment contributor (46 - 62%). Unlike the harvest estimates, which inherently include current practices; these numbers were generated using models that did not account for current road maintenance practices. In particular, the actual proportion in the Sproul Creek area is thought to be overestimated because road maintenance practices are believed to be better than assumed for modeling. This caveat does not apply to the mixed melange residential; field work in those areas found maintenance practices were poor. More work needs to be done to characterize the road construction and maintenance practices of other residential areas.

Figure 18 shows the possible magnitude of sediment from roads, including roads associated with timber production. The road related sediment estimates are dominated by stream crossing failures and hillslope gullying. This gullying refers to hillslope gullies caused by road diversions of runoff, rather than gullying of the road surface. While the estimation method used to generate these estimates is not precise (see Appendix B),

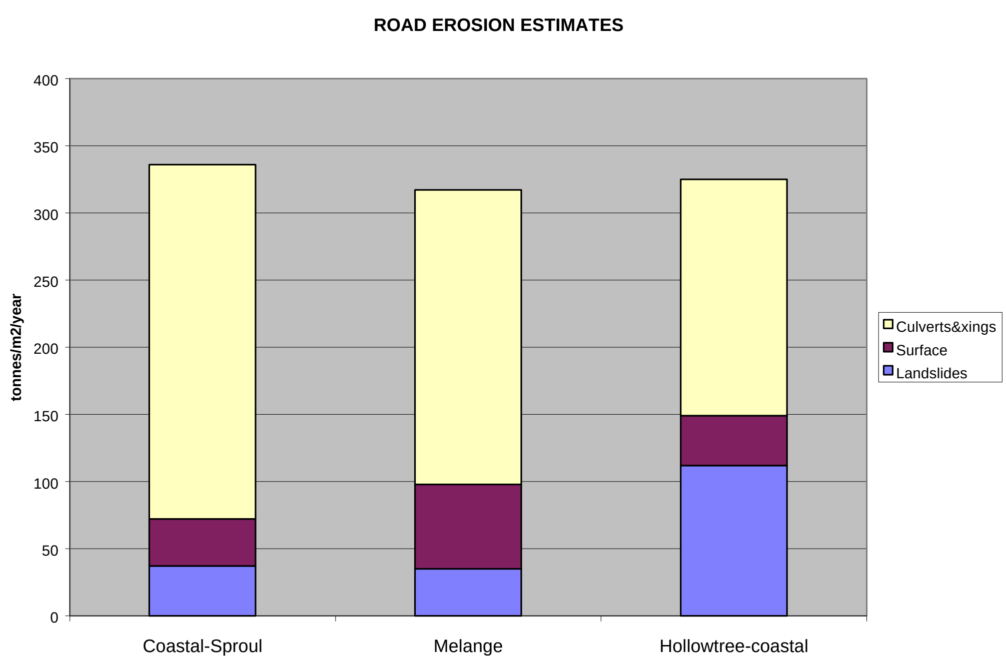


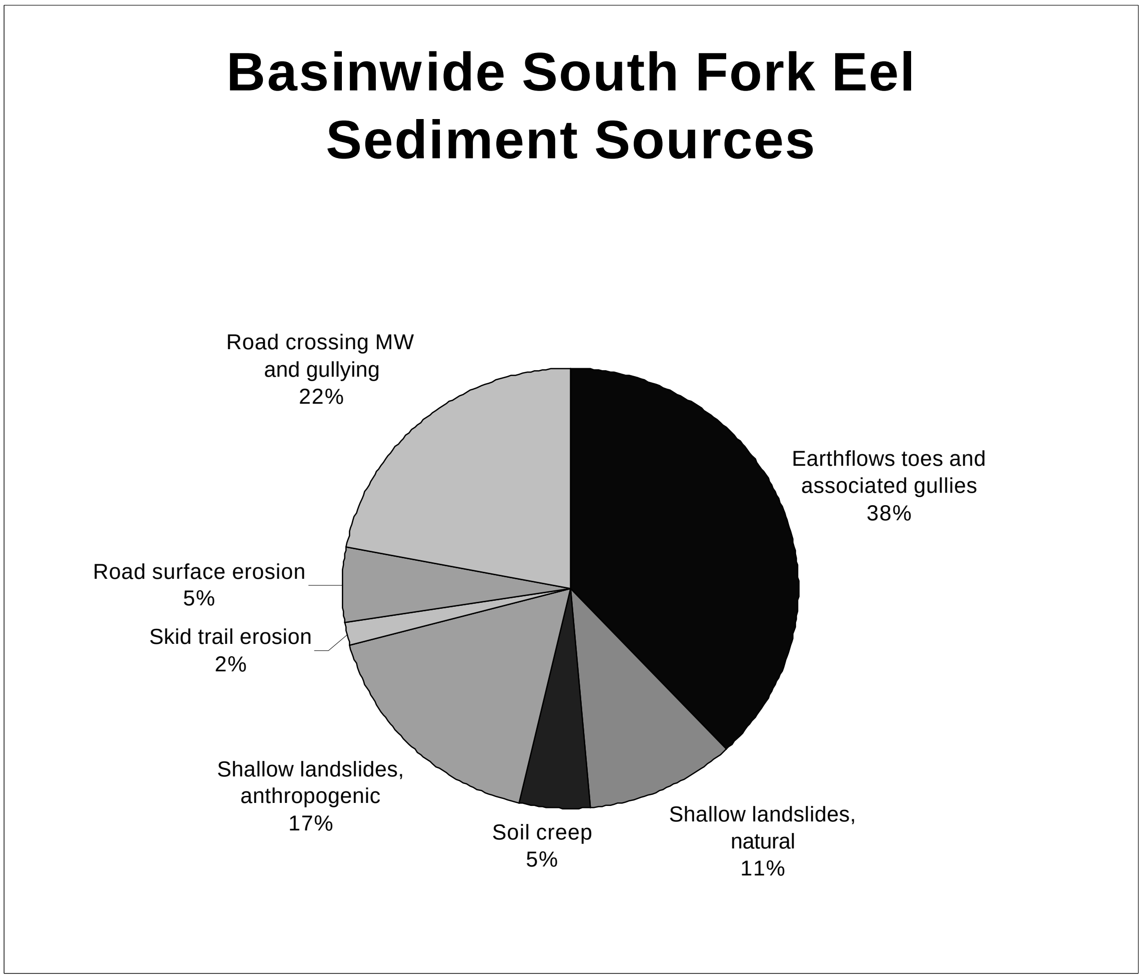
Figure 18

studies of Redwood Creek basin indicate that gullying is important contributor of sediment. Weaver, 1996 indicates that this gullying is caused mainly by improper or badly maintained culverts. Rural residential roads were estimated to as much erosion as roads associated with timber production. Although more work needs to be done to characterize residential areas road density, maintenance and construction, the results strongly imply that erosion control funding and implementation plans must take this land use into account in the South Fork Eel.

Basin wide estimates

The extrapolation of the results from the intensive study areas to the entire South Fork Eel basin estimated basin wide rates of sediment production of approximately 700 t/km2/year and a ratio of human-induced/natural sediment of 1:1. Thus, current sediment production is approximately twice the natural sediment production in the basin. Figure 19 displays the proportion of natural v. human-induced by erosion category.

Figure 19



Calculation and extrapolation methods are described fully in “Sediment Source analysis of the South Fork Eel” (Stillwater Sciences, 1999). Major techniques to produce the estimates included mapping of earthflow toes in the entire basin and mapping the entire basin in shallow landslide hazard categories using the SHALSTAB model. In addition, the intensive study areas provided rates of landsliding, road crossing failure and road surface erosion.

The results for the basin were generated for the more recent 1981-1996 period. Table 6 details the results.

TABLE 6

South Fork Eel - Basinwide Sediment Estimates

Sediment Source	Total sediment input, t/yr	Unit area sediment input (t/km2/yr)	Fraction of total
TOTAL: Natural sediment sources		**378**	**54%**
Earthflows toes and associated gullies	**478800**	**269**	**38%**
Shallow landslides, natural	**132500**	**74**	**11%**
Soil creep	**62980**	**35**	**5%**
TOTAL: Anthropogenic Sources		**326**	**46%**
Shallow landslides, anthropogenic (roads & harvest)	**216200**	**121**	**17%**
Skid trail erosion	**21534**	**12**	**2%**
Road surface erosion	**67512**	**38**	**5%**
Road crossing failures and gullying	**276500**	**155**	**22%**
Total	**1256026**	**704**	**100%**

Stillwater Sciences notes that the absolute sediment estimates (approximately 700 t/km2/yr total and 350 t/km2/year natural loading) is a fairly low estimate. EPA concludes that although the actual magnitude of sediment may be underestimated, the general conclusions are not affected. A significant proportion of sediment is still coming from human-induced sources, roads are the largest source of sediment and residential areas are important.

LOADING CAPACITY: Setting goals for sediment reduction

The TMDL program sets out a framework for meeting water quality standards. The required *loading capacity* estimates the amount of a pollutant that a stream can assimilate and still meet water quality standards. The water quality standards for sediment related concerns in the South Fork Eel all require that sediment not “adversely affect beneficial uses.” The most sensitive beneficial use in the South Fork Eel is the protection of native cold water fish. For this TMDL, EPA is proposing a loading capacity, or TMDL, that is based the ratio of human-induced sediment to natural sediment.

In developing sediment TMDLs, we have not yet been able to model or scientifically estimate the link between the amount of sediment from hillslopes (t/m2/year) and the numeric indicators of conditions in streams (V*, %fine, thalwag profile.) The nature of sediment movement in a system with variable rainfall and variable channel structure and slope make it very difficult, if not impossible, to model at a basinwide scale. Sediment movement is complex both spatially and temporally. Sediment found in some downstream locations can be the result of sediment sources far upstream; instream sedimentation can also be the result of upstream process from decades past. The fact that there are habitat effects as a result of modifications to upslope processes is well documented; however, the mathematical estimation is not established. As such, the loading capacity cannot be based on modeling or statistical relationships.

Three general approaches have been used by EPA and RB1 in setting a loading capacity for sediment TMDLs in the North Coast. They include:

- Comparing current conditions to reference streams (streams in good condition)
- Comparing current estimates to a time period that had good habitat conditions
- Relating qualitatively the proportion improvements in instream indicators to proportional hillslope erosion reduction

The approach proposed for the South Fork Eel uses the information developed in the Stillwater study on the ratio of human-caused/natural sediment to determine sediment reduction goals. This approach assumes that there is some increase over “natural” sediment that will not “adversely affect” salmon. EPA finds this a reasonable assumption because salmon populations were substantial during the 1940s, a period that included some human disturbance.

This proposed ratio approach has several potential advantages over setting loading capacity with average annual sediment loading measures, which is more commonly done in North Coast sediment TMDLs. Researchers (Stillwater, 1999) indicate that the ratio can detect management changes better than an average annual sediment loading. This is because the ratio varies with hydrology less than the annual sediment load. In addition, the average annual sediment load needs to be measured over a long time period and no one particular year may ever meet the target level. The ratio of human-induced: natural sediment could be measured periodically and provide an indication of progress toward meeting sediment reduction goals. EPA specifically encourages public comment on the use of the ratio approach as compared to setting average annual sediment load measures.

Two pieces of information were used in developing a proposed target ratio, historical data and measurement sensitivity. The historical data uses a link between fish populations in the 1940s and upslope land use. That is we assume that sediment habitat conditions in the stream and sediment production on the hillslope during the 1940s would not *in and of themselves* adversely affect salmon. This does not claim that improving sediment condition alone will lead to the salmon populations of the past, every limiting factor (i.e. temperature) must be addressed to restore salmon populations. This approach also implies that salmon populations can be self-sustaining even with the yearly variation of natural rates of erosion observed in the 20th century. So that although the sediment delivered naturally to the stream over history varied, salmon adjusted to the natural variability by using the habitat complexity created by the stream's adjustment to the natural variability. In addition, we are assuming that the natural amount of sediment can be increased by some unknown proportion and not adversely affect fish. We postulate this because there was human caused disturbance throughout the North coast when fish populations were thriving, this included ranching, the tanbark industry and some early logging.

EPA used estimates on this relationship from the following sources. Given that fish populations in the South Fork Eel were substantial during the 1940s, it would have been ideal to locate data on the ratio of human/total sediment during the 1940s in the South Fork Eel. Unfortunately, quantitative historical information for the South Fork Eel was not available. Therefore, quantitative estimates available from the Noyo River were used, the only estimates of human/natural sediment found in similar geology during the desired timeperiod. Photo analysis of the 1933-1957 is assumed to include a quiescent period between the logging of old growth at the turn-of-the-century and logging of second growth in the middle of the 20th century. The fish populations in the Noyo were substantial during this period (Manglesdorf, 1999.) The estimated rate of sediment delivery in the Noyo River watershed for the period of 1933-1957 is 468 tons/mi2/yr. Of this, 370 tons/mi2/yr is attributable to natural sources. (In reality, some of this rate is attributable to pre-industrial logging but we group all "pre-industrial" disturbances with natural causes. Of the remaining portion of the overall sediment delivery in this period (98 tons/mi2/yr), is the anthropogenic proportion, approximately rounded to **one part human-induced : four parts natural.** The proposed distribution is total sediment loads is 1 tonne/km/yr human-induced sediment for every 4 tonnes/km/year of natural sediment. This 1:4 ratio can also be expressed as 0.25.

Another consideration is measurement sensitivity. Researchers (Stillwater, 1999) indicate that sediment sources cannot be precisely measured. Thus a change from the current 1:1 ratio to 1:4 ratio would be considered relevant by researchers, but smaller changes would likely be considered in the range of measurement uncertainty.

The loading capacity calculation is as follows: Recall that the basinwide calculation of 700 t/m2/year for 1981 - 1996 estimated that human-induced: natural ratio was one:one (i.e. one part anthropogenic: one part natural.) Current natural sediment loading was estimated for the South Fork Eel at 378 tonnes/km2/yr. To obtain a ratio of 1:4, we calculate (0.25 * the natural rate or 378)= the human-induced rate or 95 t/km/yr. Therefore, averaged over a long time period under a variety of hydrological conditions, the maximum loading capacity, or TMDL, is 473 tonnes/km2/year. The loading capacity should be estimated periodically, as the ratio of anthropogenic/natural. This amount of human caused sediment should show declining trends relative to natural sediment estimates, over a range of hydrologic conditions.

In the loading capacity calculation, we propose that sediment sources be calculated on a tributary basin or smaller scale and exclude mainstem alluvial bank and terrace erosion in estimates of future man-made/natural sediment estimates. These sources should be excluded because they were excluded from the sediment source estimates and these processes cannot not be characterized by the proportion due to natural causes versus the proportion due to increased human-induced sediment loading from upstream.

Possible future refinements in the ratio are possible. EPA is interested in public comments on whether or not different ratios should be developed for different geomorphic terrains and whether the ratio should differentiate between fine and coarse sediment.

Load Allocations

The load allocation portion of a TMDL is intended to determine what types of changes are necessary to meet the loading capacity. For sediment in the South Fork Eel the major sources of sediment were found to be road-related, including roads associated with timber harvest. The load allocations in the South Fork Eel clarify the emphasis and aggressiveness of erosion control programs that need to be developed in the implementation phase. However, as we discuss further in the implementation section, EPA expects that actual sediment reduction programs as implemented by the Regional Board, will be applied to field-based assessments of sediment sources conducted by individual landowners on their properties. EPA is interested in public comments on whether or not the loading capacity ratio could be applied to these field based assessments.

In the South Fork Eel, sediment reduction plans are proposed to emphasize erosion from roads (205 t/km2/year * 0.2 = 41 t/km2/year) an 80% reduction from current levels. The roads category includes road surface erosion, road crossing failures and gullys, and skid trails. Landslides, the remaining source of anthropogenic sediment, would then need a 55% reduction from the levels calculated here (121 t/km2/year * 0.45 = 54 t/km2/year. This includes landslides from roads and landslide from harvest. Together these types of programs will result in the South Fork Eel loading capacity of 1:4 human/natural sediment production (or 473 t/km2/year.)

Margin of Safety

The Section 303(d) of the Clean Water Act and the regulations at 40 CFR 130.7 require that TMDLs include a margin of safety to account for major uncertainties concerning the relationship between pollutant loads and instream water quality. The margin of safety can be incorporated into conservative assumptions used to develop the TMDL or added as a separate, quantitative component of the TMDL (EPA, 1991).

EPA has identified a major conservative assumption that is part of the implicit margin of safety. Sediment reduction efforts can reduce the width/depth ratio of streams. This process, although it can take decades, is expected to reduce stream temperatures. This positive effect was also not accounted for in the analysis.

In addition, EPA concludes that major sources of uncertainty in the analysis will not have an influence on meeting water quality standards. The largest source of uncertainty is the conclusion by Stillwater Sciences that the sediment source analysis underestimates the total sediment loading in the basin. Prior estimates for the 1942-1966 period (USDA, 1970) were almost three times higher than the current estimated sediment production. Estimates from the Miranda gauge are also much higher for the prior time periods. The difference could be due to both the reduced runoff in the period estimated, especially the absence of the 1964 flood, and the omission of mainstem sources such as alluvial bank and terrace erosion. In addition, vegetative cover has recovered in many parts of the South Fork Eel, probably leading to lower rates of sediment delivered to streams (see Appendix B.) Because of this uncertainty, EPA set the loading capacity and allocations calculations also omitting mainstem sources. This results in more restrictive allocation calculations.

In addition, uncertainty exists in the setting of instream numeric targets. EPA has accounted for this uncertainty by using the most conservative interpretation of the science on percent fines and V*.

EPA also chose a conservative assumption in setting the loading capacity. While a **1:1** ratio of human-induced **:** natural sediment is considered too much, the ratio of 1:4 is likely an underestimate of the amount of human sediment that a stream system can process. But because no data were available between good conditions and inadequate conditions, the "maximum allowable" amount could not be determined and the most conservative assumption was used.

Overall, collection of site-specific data and refinement of the source analysis in the future will help reduce the uncertainty and eventually allow for less conservative assumptions. EPA concludes that the above uncertainties were taken into account with a sufficient margin of safety as required.

Seasonal Variation and Critical Conditions

TMDLs by law and regulation must describe how seasonal variations were considered. There is inherent annual and seasonal variation in the delivery of sediment to stream systems. For this reason, the TMDL is designed to apply to the sources of sediment, not the movement of sediment across the landscape.

The regulations also require that TMDLs shall account for critical conditions for stream flow, loading and water quality parameters. This TMDL does not explicitly estimate critical flow conditions for several reasons. First, sediment impacts may occur long after sediment is discharged, often at locations far downstream from the sediment source. Second, it is impractical to accurately measure sediment loading, and transport and short term effects during high magnitude flow events that produce most channel modification. Therefore, the approach chosen to account for critical conditions is to use indicators which are reflective of the net long term effects.

Implementation and Monitoring - Sediment

Federal regulations require the State to identify measures needed to implement TMDLs in the state water quality management plan (40 CFR 130.6). EPA expects the State to promptly develop implementation measures and ensure the implementation of erosion prevention and control measures which are adequate to acheive the TMDL.

EPA expects the State to incorporate the TMDL and an implementation plan into the Basin Plan. This requirement may be met through EPA's approval of a TMDL and implementation plan in the Basin Plan, or through incorporation of EPA-established TMDL and State-adopted implementation measures.

EPA recommends that all three major land uses should be considered in developing an implementation plan. Timber production lands can be addressed through either an erosion control program similar to that developed for the Garcia River, or possibly through the THP process, if the revised forest practice rules are established. For grazing, the Regional Board should consider the implementation procedure being developed by UC extension. EPA believes that rural residential uses, specifically roads, need to be addressed as well.

While these calculations are the best available information at this time, sediment reduction programs for the South Fork Eel could be made more effective by making information collection, and possible TMDL revision, a key part of the implementation program.

In addition, EPA specifically encourages comments on whether or not the ratio could be applied as a goal to individual erosion control plans developed on a landowner basis.

Public Participation

A Total Maximum Daily Load (TMDL) must include public participation, including: public notice, public comment, and consideration of public comment. The TMDL for the South Fork Eel will include public participation in two phases. First, U.S. EPA has and will conduct limited outreach. Second, the Regional Board through it's basin planning process will conduct more extensive public outreach during the implementation plan development.

Current outreach activities by U.S. EPA have included one informal public meeting in Garberville, a radio show and several meetings with interested parties. Planned activities include: a informational meeting, official public comment period and official hearing. In addition, notices of the availability of the draft report will be sent to local newspapers and radio stations. The report and notices of public meetings and hearings will also be available on USEPA Region 9s web site.

When the Regional Board starts the implementation planning portion of the TMDL, a formal, State-sponsored, public review process begins. The formal public review process will include opportunities to review and comment on draft and final proposals in both writing and in public forums. The Regional Water Board will consider the adoption of an amendment to its Basin Plan that describes the means by which a TMDL for the South Fork Eel watershed is to be implemented and monitored and the schedule for action. Once the Basin Plan is amended, the TMDL will become an enforceable program of the Regional Water Board.

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